A BARYONIC CORRECTION TO GENERAL RELATIVITY

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The baryon overdensity and the matching of the big bang explosion energy with gravitation can be solved by a cyclical baryonic bounce model with correction to the stress-energy tensor. Subtracting accretion energy from the CMBR allows enough baryons in nucleosynthesis to close the universe. Collapse to infinite density states must be prevented by energy losses at supranuclear densities. As long as the Einstein tensor is coupled to the stress-energy tensor, any quantum correction must involve an energy sink.

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I. INTRODUCTION: Limits on general relativity

General relativity was discovered early this century and twenty four years after its introduction, it was found to predict black holes. [15] Relativity has been extrapolated to where stars, galaxies and the whole universe could be compressed into a space smaller than an atom. There is not one shred of evidence that the universe started at Planck densities $\rho = 10^{93} g/cm^3$ and temperatures $T = 10^{31 o}K$. No high energy phenomena have been found from the first instant of creation. The nucleosynthesis of light atomic nuclei ^4He, ^2H, and ^7Li took place around densities of $10^5 g/cm^3$ and temperatures of $\sim 10^{10 o}K$, according to accepted models [18,25]. These conditions are the most extreme that has been confirmed in the big bang. Thus general relativity, as applied to the universe [21], has been extrapolated eighty orders of magnitude in density from points at which it has been validated. Only for a homogeneous, isotropic universe, the field equation has been simplified to the Friedmann equation

$$H^2 + (K/a^2) \equiv \left(\frac{\dot{a}}{a}\right)^2 + (K/a^2) = (8\pi\rho G)/3 \,, \tag{1.1}$$

where $H \equiv \dot{a}/a$ is the Hubble constant, which is time dependent. G is the gravitational constant, ρ is the mass-energy density, p is the pressure and a(t) is the scale factor of the universe, $\sim 10^{28} cm$, presently. There is always a perfect fluid in the stress-energy tensor

$$\mathbf{T}_{\alpha\beta} = \rho\mathbf{u}_\alpha\mathbf{u}_\beta + \mathbf{p}(\mathbf{g}_{\alpha\beta} + \mathbf{u}_\alpha\mathbf{u}_\beta) \,, \tag{1.2}$$

which ignores viscosity, shearing forces and subatomic effects including differences between individual baryons and bulk baryons, $n_B \gg 10^3$. Since it has been validated up to nuclear densities in pulsars, changes in the stress-energy tensor $\mathbf{T}_{\alpha\beta}$ at higher densities will be investigated.

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II. Theoretical changes necessary

The Oppenheimer and Volkoff equations of state [16] are used for neutron density matter and neutron stars up to $3x10^{14}gm/cm^3$,

$$\frac{dm}{dr} = 4\pi r^2 \rho$$

$$\frac{dp}{dr} = -(\rho + p)(m + (4\pi r^3 p))/r(r - m), \tag{2.1}$$

where m is the mass within a given radius r. Since these equations result from the field equation, information about the density change with pressure is also necessary. Neutron stars theoretically have masses up to $5M_\odot$. Single neutrons have a compression energy about 300 MeV [6]. Nuclear colliders start producing quark-gluon plasma at energies over $2x10^{12o}K \approx 184MeV$. After all the space in the neutron is eliminated $\rho > 10^{17}gm/cm^3$, the net quantum effect of further collapse and core compression must be a reversible energy sink. Since nuclear pressures can't halt a gravitational collapse, sufficient energy loss at supranuclear densities must result in a stable configuration prior to quark formation. An inhomogeneous collapse must stop when the compression energy losses of core neutrons at peak $\rho \sim 10^{18} - 10^{19}g/cm^3$ exactly match the gravitational energy, as shown in figure 1.

III. Resulting changes in our understanding

Prior to the big bang, core densities slowly increased and the energy sink of compressive losses rapidly overtook the collapse energy by an overall mass-density $\rho \sim 10^{16}gm/cm^3$. If all the matter in the universe was in a spherical mass to start, its radius was $\sim 10^{13}cm$.

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As the density rose in the core, the field disappeared and the pressure $p = \rho/3 \to 0$ in the stress-energy tensor as well. By including this energy loss, energy-momentum is conserved. With **T** and the vacuum energy $\lambda \approx 0$, an open universe existed during $t \leq 0$. No singularities ever existed since there were no infinities in energy, density or time. Accretion and other photons from previous universes were very red shifted by release into volumes $\gg$ today, so that they played no role during the open universe period. Neutron compression energy supplied $\approx 160 MeV \approx 1.85x10^{12o}K$ which propelled the farthest galaxies $\sim 0.5c$. After the bounce, the metric changed to flat. There was no difference whether the early universe was closed or open [13]. The extrinsic curvature $(6\dot{a}^2)/a^2$ was much more important than the intrinsic curvature $\pm 6/a^2$ within any hyperspace of homogeneity, since $\dot{a}^2$ was very large initially. The zones of influence were too small to respond differently to negative or positive spacetime curvatures.

The standard hot universe problems [12], can be summarized and solved with the above correction. The singularity problem follows from the scale factor of the universe a(t) vanishes as $t \to 0$ and the energy density becomes infinitely large. The inhomogeneity of matter with the energy sink and red shifting of radiation prior to the big bang caused the total energy-density $\to 0$.

The flatness problem can be stated in several ways. The ratio of the universe's mean mass density to the cold Einstein-de Sitter universe

$$\rho/\rho_c = 3H^2/8\pi\rho G \,. \tag{3.1}$$

The Friedmann-Robertson-Walker(FRW) equation implies that this ratio, which was proportional to curvature, was 1 ± 10^{-60} at the Planck era. The 'kinetic energy' $(\dot{a}/a)^2$ was equal to the gravitational mass-energy $8\pi\rho G/3$, so that $k \approx 0$ in equation (1.1). Only a bounce mechanism by which the gravitational mass-energy was converted into kinetic energy could allow the universe to be so flat. The unchanged nuclear state of the

core allows this to happen without producing quarks. $\sim$ 160 MeV was sufficient to break the shell into billions of cold baryonic masses $\leq 10^{16} M_\odot$. For mass M the gravitational radius $R_g = GM/c^2$ then

$$\rho = c^6/G^3 M^2 \,, \tag{3.2}$$

at black hole formation. Thus primordial holes could only be formed from the expanding shell neutrons in masses $\geq 4M_\odot$ if $\rho_{max} \approx 3x10^{16} g/cm^3$. If this density can not be exceeded, then smaller black holes $< 1M_\odot$ could not be formed, which would explain the missing Hawking radiation [8].

The horizon problem has to do with areas in the initial instant of creation that are too far from each other to have been influenced by initial disturbances. A light pulse beginning at t=0 will have travelled by time t, a physical distance

$$l(t) = a(t) \int_0^t dt' a^{-1}(t') = 2t \,, \tag{3.3}$$

and this gives the physical horizon distance or Hubble radius dH. In a matter dominated universe without vacuum energy $\lambda = 0$,

$$dH \approx 2H_0^{-1} \Omega_0^{-1/2} (1+z)^{-3/2} \,, \tag{3.4}$$

where $\Omega_0 = \rho/\rho_c$ in the present universe. This distance is compared with the radius L(t) of the region at time t which evolves into our currently observed area of the universe $\approx 10^{10} years$. Using a quark model near Planck conditions, this ratio l^3/L^3 is going to be very small, about 10^{-83}. Since the average baryonic density initially is $\sim 10^{16} g/cm^3$ rather than Planck densities of $10^{93} g/cm^3$, the horizon problem is diminished by a factor of $\sim 10^{77}$. Either the continuing loss of shell mass during $\mathbf{T}_{\alpha\beta} \approx \mathbf{0}$ or a major disturbance near equilibrium, will allow a nearly simultaneous release of the stored neutron compression energy. Since state data on bulk nucleons is lacking, a reduction equation

for a static system is extrapolated for compression losses of $E_{sink} = exp(\rho/2x10^{14})$ in the energy term $\mathbf{T_{\hat{o}\hat{o}}}$.

The homogeneity and isotropy problems arise due to the postulated start of the universe in such a state. The distribution of galaxies and clusters are not random on large scales. A compilation of 869 clusters has shown a quasi-regular pattern with high density regions separated by voids at intervals $\approx 120Mpc$. [4]. The CMBR has dipole anisotropy not due to our Local Group motion [11]. The universe is not isotropic on its largest scales. It has long been assumed that galaxy formation, which started after the decoupling of matter and energy, grew by gravitational amplification of small density fluctuations. With the Hubble space telescope, there is evidence that galaxies were assembled $z > 4$ [14]. Primordial galaxies, composed of hot $^1H - {}^4He$ clouds orbiting the black hole remnants of the cold shell, were already present prior to decoupling of matter and energy $z \approx 1100$. As the universe expanded and the shell remnants separated, hydrogen was efficiently removed from intergalactic space down to the Gunn-Peterson ^1H limit, and attenuated the CMBR temperature gradients as follows. Hot electrons upscattered the redshifted photons emitted by orbiting hydrogen deeper in the protogalactic wells. With decoupling, there are three types of scattering which accomplished this. [17] Thompson scattering by itself can not help thermalization because there is no energy exchange between the photons and electrons. If

$$\sigma_T = 8\pi/3(e^2/m)^2\,, \tag{3.5}$$

is the Thompson scattering cross section, then the mean-free-path for a photon between collisions is

$$\lambda_\gamma = (\sigma_T n_e)^{-1}\,, \tag{3.6}$$

where n_e is the number density of electrons. While traveling a distance l, the photon will perform a random walk and undergo N collisions where $N^{1/2}\lambda_\gamma = l$. Since Compton

scattering will not change the number of photons, it will not create a Planck spectrum. Free-free absorption at a frequency ω, is given by [17].

$$t_{ff} \cong 3(6\pi mT)^{1/2} m\omega^3/(32e^6 n_e^2 \pi^3)/(1 - e^{-\omega/T}) \,. \tag{3.7}$$

For photons with a frequency $\omega \approx T$ in electron volts,

$$t_{ff} = 2x10^{14} sec(\Omega_B h^2 x_e)^{-2} T^{-5/2} \,. \tag{3.8}$$

For ionization fraction $x_e \approx 1$,

$$t_{ff}/H^{-1} \approx (T/1.9x10^4 eV)^{-1/2}(\Omega_B h^2)^{-2} \,. \tag{3.9}$$

Thompson scattering increases the effective path length for photon absorption of free-free scattering

$$\bar{t} = 1.1x10^{11} sec. T^{-11/4}(\Omega_B h^2 X_e)^{-3/2} \,. \tag{3.10}$$

With primordial galaxies, free-free can dominate over Compton scattering between 90eV-1eV, lead to true thermalization and diminish temperature gradients in the CMBR. In FRW geometry, radiation energy $\rho_R \propto a^{-4}$ and $T \propto a^{-1}$. An increase in a(t) from $10^{13}cm.$ to $10^{28}cm.$ today would cause the corresponding temperature of CMBR would be $.00185^o K$, without the accretion energy released from the previous universe. Big bang photons are thus the small tail of the thermal spectrum near absolute zero. See for example [27] which discusses reasons for this tail. The smooth Planck spectrum at $2.73^o K$ with $\delta T/T \sim 10^{-5}$ was released by accretion during the collapse of the previous universe at $a(t) \sim 10^{22}cm.$, as shown in figure 2. The photon number density cm^{-3}

$$n_\gamma = 2.038x10^{28}T_9^3 \,, \tag{3.11}$$

where T_9 is the temperature in units of $10^{9o}K$. Therefore the photon density of the big bang is $1.29x10^{-7}.$ rather than 422. This changes the baryon/photon ratio to

$$\eta = 87.6\Omega_B h^2 \,, \tag{3.12}$$

where h is the Hubble constant in units of $100 km.sec^{-1} Mpc^{-1}$. The explosion mechanism and η are similar to that of a supernova. The hot baryon to photon ratio must be multiplied by the cold baryon factor CBF plus one to obtain the total baryon/photon ratio

$$\eta_{hot}(CBF + 1) = \eta_{total} \,. \tag{3.13}$$

A total $\eta \geq 100$ will definitely close the universe with baryons. With the kind assistance of Edward W.(Rocky)Kolb, the nucleosynthesis program NUC123 of Larry Kawano was modified. Cold baryons were calculated by multiplying the hot baryon density thm(9) in subroutine therm by the cold baryon multiplier. This was added to the total energy density thm(10) and thus to the Hubble constant. The program was compiled using the fortran77 compiler of the Absoft Corporation with the Vax compatibility option. A double precision option for all floating point variables and disabling of overflow checking allowed calculations with hot $\eta > 1$. Using cold baryons, neutrino degeneration and η as variables,it was found that $\eta = 10^{-7}$, a cold baryon multiplier 10^9 and an electron neutrino chemical potential $\xi_{\nu_e} = 1.8$ gave a D or $^2H/H = 1.9 x 10^{-4}$ and a $^4He/H = .246$. Using cold baryons allowed yields of $^2H/H > 10^{-4}$. The deuterium fraction increased with increasing cold baryons. The ^4He yields decreased with increasing electron neutrino chemical potential by reducing the neutron to proton ratio at freeze out, as first noted [25]. Doubling the cold baryons gave a $^2H/H = 2.07 x 10^{-4}$ without change to other yields. The other yields were

$$
\begin{aligned}
^3H &= 5.35 x 10^{-7} \quad ^3He = 1.4 x 10^{-5} \quad ^7Li = 1.4 x 10^{-10} \\
N &= 6.8 x 10^{-8} \quad ^6Li = 4.2 x 10^{-14} \quad ^7Be = 4.1 x 10{-11} \\
^8Li + up &= 1.7 x 10^{-15}, \,.
\end{aligned}
\tag{3.14}
$$

These are all compatable with the standard nucleosynthesis yields except the nitrogen fraction which has $N = 5.6 x 10^{-16}$. The low estimate deuterium fraction now in favor

$(1-2)x10^{-5}$, could be made with the same neutrino degeneration, $\eta = 10^{-6}$ and cold baryon factor of 10^9 as well as $\eta = 10^{-7}$ and a cold baryon factor of $2x10^8$. The last case probably hasn't sufficient baryons to close the universe.

Galaxy formation problems [19] are greatly simplified. An explosive universe with galaxy formation will fit the large scale galactic pattern [26]. Although the Jeans mass is thought to be the point at which gravity overcomes pressure to form galaxies, massive rotating primordial black holes may be necessary for galactic structure. In the Tully-Fisher relation

$$V_c = 220(L/L_\star)^{.22} , \tag{3.15}$$

and Faber-Jackson

$$V_c = 220(L/L_\star)^{.25} , \tag{3.16}$$

where V_c is the circular velocity km/sec and $L_\star$ is the characteristic galaxy luminosity. The former relation is for velocities in the dark halo of spiral galaxies and the latter for star velocity dispersion in central parts of elliptical galaxies [20]. Rotational energy is a function of MV_c^2. Galactic brightness results from ^1H mass, M_{galaxy}. The black hole capturing cross section

$$\sigma_{capt.} = 16\pi M^2/\beta^2 , \tag{3.17}$$

where β is the particle velocity relative to light [13]. Because of the ^1H capture by primordial black holes, the brightness is proportional to the central nuclear mass $M_{nucleus}^2$. With $M_{nucleus}^2 V_c^4 = $ constant, $M_{nucleus}V_c^2$ is constant related to the rotational energy imparted prior to the big bang. Thus Tully-Fisher can relate the stellar galactic mass and luminosity to the depth of the dark matter potential well and asymtotic circular speed. Due to the capture mechanism of ^1H, the black hole nuclear mass $M_{nucleus} \propto M_{galaxy}$.

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Galaxy formation never involved collapse dynamics with its different post collapse densities, circular speeds and disk assymetries.

The quantization of galactic redshifts found in even multiples of 37km./sec. by W.G. Tifft [22,23,24] and other workers [2,1,9] and also [3,7] is persuasive evidence that the cold baryonic shell, which formed galactic nuclei and quasars, was present already at the big bang. Its different layers received different energies from the hot expanding core, even producing supermassive black holes. Near Abell 3627 there is a mass $5x10^{16}M_\odot$, the Great Attractor [10], which must result from a large initial homogeneity. It may be near the original site of the big bang. The explosion mechanism described here is apparently that in the Hebrew Bible.

The baryon asymmetry problem has been stated as to why there are many more baryons than antibaryons. Baryon-antibaryon pairs are only created from a vacuum at energies $> 10^{13o}K$, which is higher than the $160MeV \approx 1.85x10^{12o}K$ core temperature. Extreme energy phenomena such as domain walls, monopoles, gravitinos and symmetry breaking were not reached in big bang.

IV. A cyclical universe

Although equation 1 is cyclical, it is valid only for a universe that is isotropic and homogeneous i.e. a perfect fluid. In figure 2, the maximum scale factor a_{max} of the universe is equal to the gravitational radius

$$R_g = GM/c^2 \sim 10^{29}cm\,.\tag{4.1}$$

After a_{max} was reached, the galaxies were blue shifted as they reconverged. When a(t) was 10^6 smaller than today, the proportionately higher CMBR tore neutrons and protons

from nuclei. In the center was a growing black hole resulting from merging galactic nuclei. Stars and galaxies were accreted onto this supermassive black hole in a massive thick disk. Once the mass of this black hole exceeded the size of an average galactic nucleus $\sim 10^8 M_\odot$, tidal forces were no longer capable of tearing a star apart before it entered R_g with relatively little radiative losses [5]. The collapsing scale factor a(t) forced all the matter and released energy inside the growing R_g in a Schwarzschild gometry. Then $R_g \to 0$ as the spacetime propogation of the core energy losses slowly reduced the potential barrier of the supermassive black hole.

V. DISCUSSION

Although classical general relativity has been confirmed to one part in 10^{12}, it must break down prior to the infinite densities of singularities. There is no reason why a small mass $> 4M_\odot$ can contract to a singularity while the mass of universe explodes into the big bang. If a star surface lies entirely inside the R_g, classical relativity concludes from Kruskal-Szekeres diagrams that it must collapse to a singularity or faster than the speed of light. Here coordinate reversal occurs, $\partial/\partial r$ is timelike ($g_{rr} < 0$) and proper time at the surface

$$\tau = -\int^R [g_{rr}]^{1/2} dr + constant \,. \tag{5.1}$$

In order to allow a big bang, a reduction in the stress-energy tensor must occur before enormous densities and energies are reached inside R_g. As $\mathbf{T} \to \mathbf{0}$, the impetus for further collapse stops with eventual elimination of the future event horizon. After equilibrium is established, there is re-reversal of the time coordinate and no further reduction in size. The quantum requirement that $\mathbf{T} > \mathbf{0}$, will not be violated as it will approach zero on the positive side. A solution to the covariant perturbation problem for quantum

gravity would be as follows. The spacetime metric g_{ab} is divided into a flat Minkowski component β_{ab} and its deviation γ_{ab}, where $(M, {}^o g_{ab})$ is a solution to the field equation. The field equation can be seen as an equation for a self interacting spin-2 field γ_{ab} in Minkowski spacetime. In the first order γ_{ab} is a free spin-2 equation with much gauge arbitrariness which can be expanded into a perturbation series for non-abelian gauge fields. Although this part is non-renormalizable, the energy sink correction eliminates this term at high energies leaving the background metric β_{ab} which satisfies causality conditions. The quantum mechanism by which the energy sink suppresses vibratory and other modes remains to be elucidated. The problem of evaporation for black holes under a solar mass due to quantum particle creation with violation of lepton and baryon conservation is avoided. Naked and all other singularities are mathematically eliminated. Black holes can eventually influence their surroundings to achieve thermal equilibrium. Thus there is no loss of quantum coherence as the final black hole state will be a pure one and the scattering matrix S deterministic. Supernovas $< 4M_\odot$, when collapsing to the same limiting density, will bounce without blackhole formation. A supranuclear equation of state based on actual data (which does not yet exist) or more accurate primordial deuterium ambundance would better determine the shell to core mass ratios and the bounce temperature.

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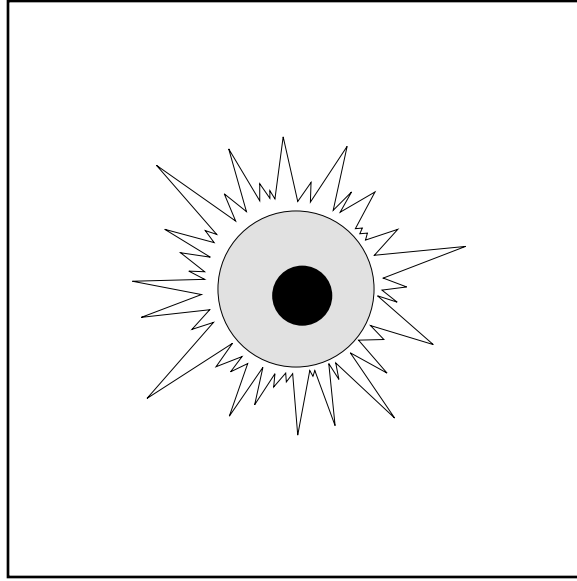
FIG. 1 Inhomogeneous explosion mechanism at t=0, dictated by matching of kinetic energy with gravitational energy, i.e. the flatness problem. The shell became galactic nuclei, dark matter and quasars. The hot core became the initial ^{1}H-^{4}He.

Figure 2. Cyclical Universe

nuclear compression, spacetime propagation

R_g

a(t)

scienties photons released

valid FRW geometry

a(t)

big bang photons released

Gravitational radius Rg or scale factor a(t), cm.
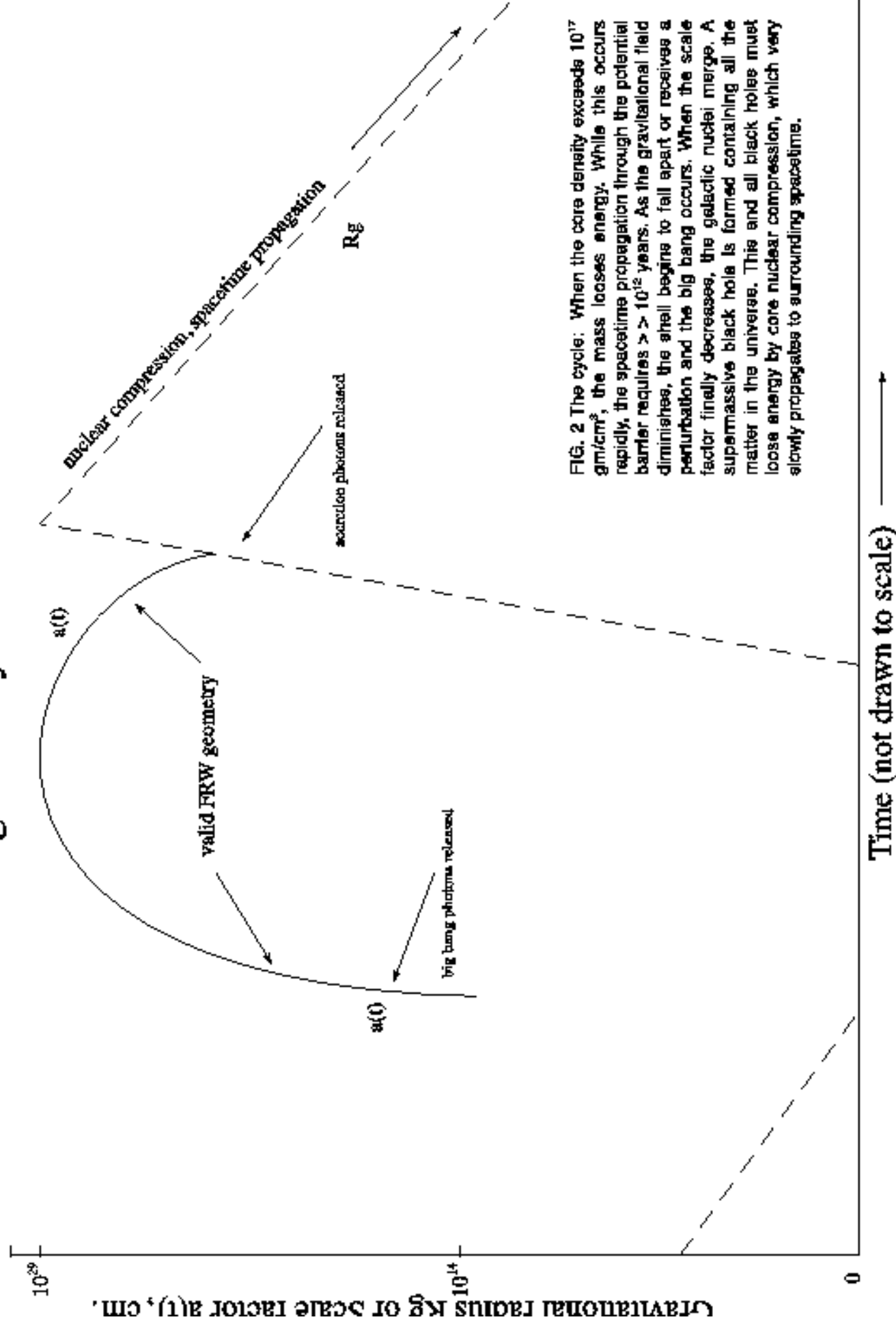
10^{29}

10^{14}

0

Time (not drawn to scale) ⟶

FIG. 2 The cycle: When the core density exceeds 10^{17} gm/cm³, the mass looses energy. While this occurs rapidly, the spacetime propagation through the potential barrier requires $>> 10^{12}$ years. As the gravitational field diminishes, the shell begins to fall apart or receives a perturbation and the big bang occurs. When the scale factor finally decreases, the galactic nuclei merge. A supermassive black hole is formed containing all the matter in the universe. This and all black holes must loose energy by core nuclear compression, which very slowly propagates to surrounding spacetime.